MEDALION JOURNAL: Medical Research, Nursing, Health and Midwife Participation | ISSN(e): 2986-7754
Volumes 6 No. 2 (2025)

THE RELATIONSHIP BETWEEN THE CHEMICAL PROPERTIES OF SOIL AND THE COMPOUNDS SQUALENE AND LINOLENIC ACID

Aditya Candra[1]*, Tahara Dilla Santi[2], Ika Waraztuty[3], Andri[4], Muhammad Yani[5], Said Aandy Saida[6]
Faculty of Medicine, Universitas Abulyatama, Indonesia[1,4,5,6]
Faculty of Public Health, Universitas Muhammadiyah Aceh, Indonesia[2]
Faculty of Medicine, Universitas Syiah Kuala, Aceh[3]
Department of Public Health,Universitas Syiah Kuala, Aceh[5]
Corresponding E-mail: dr.adityacandra@gmail.com

Received : 21 March 2025	Published : 26 May 2025
Revised : 30 March 2025	DOI : https://doi.org/10.59733/medalion.v6i2.192
Accepted : 17 April 2025	Link Publish : https://medalionjournal.com/index.php/go

Abstract

This research aims to determine the concentrations of secondary metabolites in Carica papaya (papaya) leaves and their correlation with soil chemical properties in Aceh Besar. Purposive sampling was used to select papaya plant leaves from the Kajhu and Ie Seuum areas for this study. Soil samples were collected from where the papaya leaf samples were obtained. Utilization of the maceration technique for extracting papaya leaves and identifying secondary metabolite compounds via Gas Chromatography Mass Spectrophotometry (GCMS). The chromatogram results indicated that squalene and linolenic acid were the compounds with the highest percentages. At the same time, the soil samples were subsequently analyzed for N, P, K, C, pH, and temperature content. Subsequently, the acquired data were subjected to multiple regression analysis. The findings indicated that the squalene content was 3.2–3.35% in Kajhu and 10.4–10.5% in Ie Seum, whereas linolenic acid levels were 10.18–10.21% and 4.03–4.05%, respectively. The squalene content positively correlates with P, pH, and temperature, whereas linolenic acid correlates solely with the P elements. The chemical properties of the soil do not significantly influence the content of squalene and linolenic acid.

Keywords: ***papaya leaves, soil, chemical properties, GCMS, squalene, linolenic acid***

INTRODUCTION

The Carica papaya plant is native to Indonesia, India, Malaysia, Sri Lanka, the Philippines, and Oman and thrives in tropical regions. In Asia, aside from its role as a garden plant, it is utilized as a medicinal component for commercial purposes, with all its parts serving as herbal remedies for various ailments (Candra & Santi, 2017; Nugroho et al., 2017; Santi, Zakaria, et al., 2023; Wadekar et al., 2021). Soil is a crucial component of land that significantly influences plant growth and production. It serves as a medium for plants to grow and retains and supplies water for them. Additionally, soil provides essential nutrients that support plant growth (Candra, Fahrimal, et al., 2023; Moebius-Clune et al., 2016; Santi, Zakaria, et al., 2023; Santi & Candra, 2024). Various factors influence soil formation, including climate, parent material, topography or relief, organisms, and time. Various soil-forming factors will have differing degrees of influence, leading to the development of specific physical, chemical, and biological characteristics of the soil. These characteristics will ultimately impact the fertility of that soil. Thus, it is highly inappropriate to generalize soil fertility status on land with a different physical environment (Bünemann et al., 2018; Santi, 2019; Santi & Candra, 2024)

Herbal remedies have emerged as a treatment option and are gaining popularity due to the belief that natural remedies are healthy, with the WHO even recommending their use. Carica papaya is a widely known plant in the medical field, and it is known for its medicinal properties. Carica papaya acts as an anti-inflammatory, antioxidant and wound healing agent. Its chemical compounds, such as squalene and linolenic acid, are significant in health and treating diseases (hypertension, diabetes mellitus) (Candra, Santi, et al., 2023; Santi, Candra, et al., 2023)(Candra, A., Santi, T., Yani, M., Mawaddah, 2022; Santi, 2019; Ullya et al., 2024).

Consequently, scientists examined how the chemical characteristics of soil influenced the compounds and bioactivity of papaya leaves in the Kajhu area (coastal) and Ie Seum (geothermal). This research aims to establish how soil physical properties relate to papaya leaf phytochemistry. The relationship between the secondary metabolites of papaya leaves and soil chemical properties (NPK), pH, and temperature was examined through data analysis using multiple linear regression testing.

LITERATURE REVIEW

Medicinal plants are essential for synthesizing important substrates, enhancing stress resilience, and providing services in both clinical and industrial fields. To optimize pharmacological potential, it is necessary to have a detailed understanding of the factors that control the synthesis of secondary metabolites from plants (Candra, Fahrimal, et al., 2024; Santi & Candra, 2023). The papaya plant is a tropical species that grows extensively in Indonesia. Papaya stands out among herbal plants due to its distinct shape. Papaya, as a herbal plant, offers numerous health benefits including anti-inflammatory, antioxidant, antifungal, and antibacterial properties(Candra, Santi, et al., 2024; Onyedikachi et al., 2024; Santi, 2015). The success of cultivation depends on various factors that influence the production of these essential compounds. Medicinal plants' growth, development, and metabolic pathways are collectively influenced by biotic factors like pathogens and herbivores, as well as abiotic factors such as light exposure, altitude, temperature variations, irrigation patterns, soil fertility, drought susceptibility, and salinity levels (Alami et al., 2024; Santi et al., 2022).

Soil is a crucial component of land for plant growth and production. It serves as a medium for plants to grow in, providing them with air and anchorage, and also plays a vital role in supplying the nutrients necessary for their development (Hein et al., 2023; Moebius-Clune et al., 2016; Santi et al., 2025). When considered collectively, our experiments demonstrate that secondary metabolite-producing plants can condition soil to enhance yield through plant-soil feedback mechanisms, all within the bounds of realistic agronomic conditions. Should this phenomenon apply to various soils and contexts, optimizing the chemistry of root exudation could serve as a potent strategy for enhancing crop yields without extra inputs, particularly given its genetic tractability. Key environmental factors that influence the synthesis of secondary metabolites include light intensity, water availability, temperature, soil composition, and biotic interactions. Plants' secondary metabolism of compounds like alkaloids, terpenoids, and flavonoids can be regulated by enhanced light intensity (Alami et al., 2024; Santi & Candra, 2024)

METHOD

Sample collection

Samples of papaya leaves were collected from two sites in Aceh Besar, specifically Kajhu and Ie Seum. Subsequently, the leaves were rinsed with tap water for 5 minutes and then dried. The dried leaves were processed into powder and sieved by a grinding machine. The samples were kept in an airtight glass container at 4°C until extraction.

Preparation of the Extracts

Two hundred fifty grams of dried papaya leaves were dissolved in 1000 ml of ethanol and left for 24 hours. The suspension was filtered using a Whatman filter paper. A rotary evaporator concentrated the filtrate at 45°C and under reduced pressure.

GC-MS analysis

GC-MS analysis was performed in the Chemical Laboratory of the Faculty of Mathematics and Natural Sciences at Syiah Kuala University in Banda Aceh City, utilizing an Agilent Technologies 7890 GC system linked to an Agilent Technologies 5977. The Pubmed database was used as an extra resource to verify the identity of compounds.

Chemical Soils Analysis

The tools and materials used in this study comprise 1000 grams of papaya leaves, distilled water, 90% ethanol, a maceration container, filtrate bottle, filter paper, glassware, rotary evaporator, GC-MS, a 4 in 1 Soil Analyzer digital tool, paper, porcelain mortar, a 0.5mm sieve, label paper, analytical balance, spoon, glass funnel, a 50ml flask, a 5mL pipette, dropper, 100ml beaker, spatula, spray bottle, sample basket, cuvette, UV-Vis spectrophotometer (also analytical balance), a 100ml shake bottle and a 50ml dispenser measuring cup-1 shaker as well as a 500ml spray flask

pH meter aluminum plate stainless steel clamp oven desiccator filter paper test tube centrifuge filled pipette percolation tube spray flask flame photometer digestion tube AAS.

Carbon Organic Determination

Weigh 0.500 g of soil sample size <0.5 mm, and put it into a 100 ml measuring flask. Add 5 ml of $K_2Cr_2O_7$ 1 N, then shake. Add 7.5 ml of concentrated H_2SO_4, shake, then let stand for 30 minutes. Dilute with deionized water, let cool, and compress. The next day, the absorbance of the clear solution was measured with a spectrophotometer at a wavelength of 561 nm. For comparison, 0 and 250 ppm standards were made by pipetting 0 and 5 ml of a 5,000 ppm standard solution into a 100 ml measuring flask.

Kjeldahl Nitrogen Determination

a. Sample destruction.

Place a soil sample of <0.5 mm, weighing 0.5 g, into a digest tube. Incorporated 1 g of selenium mixture and 3 ml of concentrated sulfuric acid, destroyed at 350 ^oC for 3-4 hours. Destruction is completed when a clear extract is produced and white vapor emerges, which takes around 4 hours. The tube is raised and cooled, and the extract is mixed with deionized water to achieve a total volume of precisely 50 ml. Shake until uniform, and let it sit overnight for the particles to settle. The extract serves for N measurement via the distillation or colorimetric method.

b. N measurement.

N measurement via distillation. All sample extracts were qualitatively transferred into a boiling flask (utilizing deionized water and a spray flask). To half the volume of the flask, a little distilled water and boiling stone powder are added. Get an Erlenmeyer flask ready, containing 10 ml of 1% boric acid and three drops of Conway indicator (red) linked to the distillation apparatus. This will serve as a container for the released NH3. Using a measuring cup, 10 ml of 40% NaOH is added to the boiling flask with the sample and immediately sealed. Continue distilling until the container's volume is reduced to 50–75 ml (green).

The distillate is titrated with 0.050 M H2SO4 until a pink color appears. The volumes of the sample (Vc) and blank (Vb) used in titration are noted for the measurement of N with a spectrophotometer. Transfer 2 ml of each extract and standard series into a test tube using a pipette. Solutions of tartrate and Na-phenate are added one after the other, each measuring 4 ml, then shaken and allowed to sit for 10 minutes. After adding 4 ml of 5% NaOCl and shaking, the sample is measured with a spectrophotometer at a wavelength of 636 nm, 10 minutes after this reagent was added.

Determination of P and K

Weighed 2.5 g of soil sample <2 mm, added 25 ml of Bray and Kurt I extractor, then shaken for 5 minutes. Filtered and, if the solution is cloudy, returned to the original filter (filtering process maximum 5 minutes). Pipette 2 ml of clear extract into a test tube. Samples and standard series were each added with 10 ml of phosphate dye reagent, shaken, and left for 30 minutes. The absorbance was measured with a spectrophotometer at a wavelength of 889 nm.

Determination of pH

Weigh 10 g of soil sample twice, each put into a shaker bottle, add 50 ml of deionized water to one bottle (pH H2O) and 50 ml of 1 M KCl to the other bottle (pH KCl). Shake with a shaker machine for 30 minutes. The soil suspension is measured with a pH meter calibrated using buffer solutions of pH 7.0 and pH 4.0. The pH value is in one decimal. The pH value indicates the concentration of H+ ions in the soil solution, which is expressed as -log[H+]. An increase in H+ concentration increases the potential of the solution measured by the instrument, which is converted to the pH scale. The electrode glass is a special electrode specifically for H+, so it only supports measuring the potential that causes an increase in H+ concentration. The potential that arises is measured based on the potential of the reference electrode (calomel or AgCl). The concentration of H+ extracted with water indicates active acidity (actual), while the 1 M KCl extract indicates reserve acidity (potential).

Determination of soil temperature

Soil temperature is measured using a 4-in-1 Soil Analyzer digital tool. The tool is inserted or stuck into the soil. Next, the measuring tool is set according to the temperature setting. Let it stand for a moment, and the temperature measurement results are displayed on the monitor.

RESULTS AND DISCUSSION

Secondary Metabolite Content of Papaya Leaves

The secondary metabolite content tested was a compound found through GC-MS analysis of papaya leaves from Kajhu and Ie Seum, namely squelene and linolenic acid. Based on the research results, the squelene content in the Kajhu area was 3.2-3.35%, and in the Ie Seum area was 10.4-10.5%, while the linolenic acid compound in Kajhu had a percentage content of 10.18-10.21%, and in Ie Seum it was 4.03-4.05% (Table 1).

Table 1. Chromatogram of Papaya Leaves in Aceh Besar

No	Phytocompounds	Ie Seum		Kajhu	
		Rate Time	**%**	**Rate Time**	**%**
1	Hexadecanoic acid, ethyl ester	28.75	2.12	28.57	1.88
2	Neophytadiene	27.41	1.89	27.59	1.32
3	Squalene	33.24	10.42	32.95	3.33
5	Gamma-tocopherol	35.64	1.44	35.16	3.70
6	Linolenic acid	30.06	4.04	29.92	10.19

GC-MS analysis in Table 1 shows papaya leaf's RT value and compound content from 2 locations. These compounds act as anti-inflammatory and antioxidant. In the study, researchers focused on two secondary metabolite compounds, namely squalene and linolenic acid, because they have the highest Kajhu or Ie Seum content. This is by research by Seadi, Ugo, de Alencar, Halim, and Pejin showing that *Carica papaya* plants contain compounds that act as anti-inflammatory and antioxidant, such as neophytadiene, 9,12,15 octadecatrienoic acid; squalene (Al-Seadi et al., 2021; Ghosh et al., 2021; Jalalvand et al., 2019; Seigler et al., 2002).

Analysis of Soil Chemical Properties

The results of the analysis of soil chemical properties of Kajhu and Ie Seum soil samples are shown in Table 2.

Table 2. Analysis of soil chemical properties in Ie Seum

District	**Chemical Properties**					
	K (%)	**P (mg kg^{-1})**	**C (%)**	**N (%)**	**pH**	**Temperature (^{0}C)**
Ie Seum	0.54	3.70	0.89	0.11	7.6	35
Kajhu	0.99	51.35	0.88	0.13	8.1	37

Multiple linear regression analysis was used to see the relationship between the variables N, P, K, C, pH, and temperature with squelene and linolenic acid in Kajhu and Ie Seum. The results of the analysis of the variables N, P, K, C, pH, and temperature with squelene in Kajhu can be described as a multiple regression equation as follows:

$$Y = \alpha + \beta1X1 + \beta2X2 + \beta3X3 + \beta4X4 + \beta5X5 + \beta6X6 + e$$
$$Y = 6.806 - 2.989X1 - 4.140X2 - 0.013X3 + 2.292X4 - 1.31X5 + 0.012X6 + e \ldots\ldots\ldots\ldots (1)$$

The equation above shows a unidirectional influence between the independent and dependent variables. This shows that if all independent variables, including N (X1), K (X2), P (X3), C (X4), pH (X5), temperature (X6), have a value of 0% or do not change, then the squelene value is 6.806. The results of the multiple linear regression test of linolenic acid and K, P, N, C, pH, and temperature in Kajhu are formulated in the equation:

$$Y = 25.527 - 0.752X1 - 1.692X2 - 0.270X3 - 0.033X4 + 0.019X5 + 0.004X6 + e \ldots\ldots\ldots(2)$$

This shows that the independent variables, including N (X1), K (X2), P (X3), C (X4), pH (X5), and temperature (X6), have a value of 0% or do not change, and the linolenic acid value is 25.527. The results of the multiple linear regression analysis for squelene in the Ie Seum area can be written as the following equation:

$$Y = 15.855 + 2.845X1 - 3.535X2 - 0.047X3 + 1.615X4 - 0.611X5 - 0.013X6 + e \ldots\ldots\ldots(3)$$

This equation shows that the independent variable has a value of 0% and squelene has a value of 15.855. While for the linolenic acid compound, the equation obtained is:

$$Y = 3.273 + 0.707X1 – 1.021X2 - 0.011X3 + 0.826X4 + 0.061X5 + 0.002X6 + e……...(4)$$

The independent variable has a value of 0% with a linolenic acid value of 3.273. The laboratory analysis results show that the soil pH in Kajhu and Ie Seum is classified as neutral and slightly alkaline. The pH value shows the concentration of hydrogen ions (H+) in the soil; the higher the level of H+ ions in the soil, the more acidic the soil is. Soil pH provides the biological atmosphere of the soil and provides soil nutrients for plants in good condition (Candra, Fahrimal, et al., 2023; Isir et al., 2022; Santi, Siregar, et al., 2023).

The organic C content in Kajhu and Ie Seum is very low. Soil organic matter is all the carbon in the soil from dead plant/vegetation and animal remains. Most sources of soil organic matter are plant/vegetation tissues. Different sources and amounts of organic matter will have different effects on the organic matter contributed to the soil. If the addition rate is lower than the decomposition rate, the soil organic matter will decrease and vice versa. Low organic C will cause easy water loss (evaporation), some macronutrients, and resistance to drying(Rahmi & Biantary, 2014; Santi & Candra, 2024).

Total N content in Kajhu and Ie Seum is low. This condition is caused by the N content coming from organic matter. Suppose the provision of organic matter from vegetation growing above the soil is small. In that case, the vegetation contributing organic matter is lacking, so what happens in the soil is poor in N elements. Munawar (2011) stated that several factors influence the addition of soil organic matter, including soil management, soil texture, climate, and type/kind of vegetation. Rahmi (2014) added that vegetation growing above the ground and its decomposition rate are factors causing changes in the N content in the soil. All forms of N in the soil will be converted or oxidized into NO^{3-}, which then becomes the subject of reactions/processes, one of which is leaching, so that the form of NO^{3-} in the soil is volatile. The N element in the soil can be lost because plants or microorganisms use the N element, and the leaching process (washed away by rainwater) occurs, especially N in the form of NO^{3-}. So it can be assumed that if it rains often, the N element will be low because of the leaching process (Hardjowigeno, 2007; Munawar, 2013; Rahmi & Biantary, 2014).

An essential environmental component that affects enzyme activity and metabolic pathways, influencing the synthesis of secondary metabolites, is temperature (Jamloki, Bhattacharyya, Nautiyal, & Patni, 2021; Qaderi, Martel, & Strugnell, 2023). Research has demonstrated that temperature variations can impact the diversity, concentration, and makeup of secondary metabolites produced by marine species, microorganisms, and plants (Holopainen et al., 2018; Salam et al., 2023). A rise in temperature speeds up the aging process of plant leaves and the buildup of secondary metabolites (Figure 10).

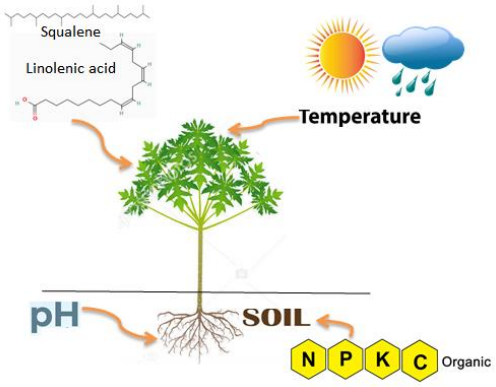

Figure 1. The relationship between N, P, K, C, pH and temperature with phytocompounds of papaya leaves

It should be underscored that thermal stress significantly hinders plant development and induces senescence, despite evidence of its role in enhancing or diminishing the production of secondary metabolites in plants. The content of root ginsenosides in plants of the genus increases with temperature elevation. During the overwintering season, temperate plants generate specific cryoprotectant molecules. This group of molecules comprises soluble sugars (such as trehalose, stachyose, saccharose, and raffinose), sugar alcohols (like sorbitol, ribitol, and inositol), low-molecular-weight nitrogenous substances (including proline and glycine betaine), protective antifreeze proteins, and others. Lignification and suberin deposition in plant cell walls increase resistance to low temperatures(Ahl & Omer, 2011; Khan et al., 2020).

Cold stress denotes temperatures under 20 °C, adversely affecting plant growth and development and significantly diminishing their production. It prevents plants from realizing their full genetic potential, directly restricting metabolic responses and indirectly limiting water absorption and cellular dehydration. This stops plants from attaining their complete genetic potential. Cold stress decreases chlorophyll and total chlorophyll levels, while the amount of apoplastic and total soluble protein in the leaf rises. The research findings indicate that cold stress significantly affects the variation in the number of PSMs present (Alami et al., 2024; Candra & Santi, 2017; Koç et al., 2010).

CONCLUSION

The phytochemical properties of plants vary according to geographical location, variety, season, processing method, and other activities. The soil in Kajhu and Ie Seum has chemical characteristics obtained in the form of neutral pH and tends to be alkaline, organic C is still very low, N in a low percentage, exchangeable base cations, namely K, are relatively low, and the temperature is stable (not too cold and not too hot) so that the soil in the Kajhu and Ie Seum areas can be a habitat for Carica papaya plants. The results showed that the independent variables were insignificant to the dependent variable.

REFERENCES

Ahl, H., & Omer, E. (2011). "Medicinal and aromatic plants production under salt stress." A review. *Herba Polonica*, *57*, 72−87. https://doi.org/doi: 10.3001/0053.2789

Al-Seadi, H. L., Sabti, M. Z., & Taain, D. A. (2021). "GC-MS Analysis of Papaya Leaf Extract (Carica Papaya L.)". *IOP Conference Series: Earth and Environmental Science, Volume 910, Fourth International Conference for Agricultural and Sustainability Sciences 4-5 October 2021, Babil, Iraq*.

Alami, M., S, GuoZ, M., Yang, G., & X, W. (2024). "Environmental factors on secondary metabolism in medicinal plants: exploring accelerating factors." *Medicinal Plant Biology*, *3*(16). https://doi.org/doi: 10.48130/mpb-0024-0016

Bünemann, E. K., Bongiorno, G., Bai, Z., Creamer, R. E., De Deyn, G., & de Goede, R., Fleskens, L., Geissen, V., Kuyper, T. W., Mäder, P., Pulleman, M. M., Sukkel, W., van Groenigen, J. W., and Brussaard, L. (2018). "Soil quality – A critical review, Soil Biol." In *Biochem* (120th ed., pp. 105–125).

Candra, A., Santi, T., Yani, M., Mawaddah, D. (2022). Skrinning Tekanan Darah pada Masyarakat Desa Baet Lampuot Tahun 2022. *Jurnal Abdimas UNAYA*, *3*(2), 15–20. http://jurnal.abulyatama.ac.id/index.php/Abdimas

Candra, A., Fahrimal, Y., Yusni, Azwar, & Santi, T. D. (2023). Soil Chemistry, Phytochemistry, and GC-MS Profils of Moringa Leaves (Moringa oleifera) as an Antifatigue Candidate From Geothermal, Coastal, and Urban Areas in Aceh Besar District and Banda Aceh Municipality, Indonesia. *Rasayan Journal of Chemistry*, *16*(3), 1333–1341. https://doi.org/10.31788/RJC.2023.1638128

Candra, A., Fahrimal, Y., Yusni, Azwar, & Santi, T. D. (2024). Phytochemistry and antifatigue activities of Carica papaya leaf from geothermal, coastal and urban areas, Indonesia. *Narra J*, *4*(1), 1–9. https://doi.org/http://doi.org/10.52225/narra.v4i1.321

Candra, A., & Santi, T. D. (2017). Efektivitas Ekstrak Daun Pepaya (Carica papaya L) sebagai antiinflamasi. *Jurnal Aceh Medika*, *1*(2), 63–66. http://jurnal.abulyatama.ac.id/index.php/acehmedika/article/view/145

Candra, A., Santi, T. D., Yani, M., & Maidayani, M. (2023). Sosialisasi Pencegahan Stunting di Wilayah Kerja Puskesmas Kuta Malaka. *Jurnal Abdimas Unaya*, *4*(1), 6–11. http://jurnal.abulyatama.ac.id/index.php/Abdimas/article/view/3928/pdf_1

Candra, A., Santi, T. D., Yani, M., Saida, S. A., Waraztuty, I., & Bastian, F. (2024). Differences In Pulse Rate And Lactic Acid Levels In Athletes Before And After Light And Medium Intensity Physical Activities. *Medalion Journal*, *2*(2), 75–80. https://medalionjournal.com/index.php/go/article/view/113/111

Ghosh, A., Majumder, S., Saha, S., Sarkar, S., & Bhattacharya, M. (2021). Gas Chromatography-Mass Spectrometry profiling, and evaluation of antioxidant and antibacterial activity of Albizia spp. *Nusantara Bioscience*, *13*(2), 177–184. https://doi.org/10.13057/nusbiosci/n130207

Hein, P. P., Arunachalam, K., Fu, Y., Zaw, M., Yang, Y., & Yang, X. (2023). Diversity of medicinal plants and their therapeutic usages of Kachin people (Jinghpaw) in the central part of Kachin State, Myanmar. *Journal of Ethnopharmacology*, *302*(2), 115921. https://doi.org/https://doi.org/10.1016/j.jep.2022.115921

Isir, S., Tamod, Z. E., & Supit, J. M. J. (2022). Identifikasi Sifat Kimia Tanah Pada Lahan Tanaman Bawang Merah (Allium ascalonicum,L.) Di Desa Talikuran Kecamatan Remboken Kabupaten Minahasa. *Soil Environmental*, *22*(1), 6–11.

Jalalvand, A. R., Zhaleh, M., Goorani, S., Zangeneh, M. M., Seydi, N., Zangeneh, A., & Moradi, R. (2019). Chemical characterization and antioxidant, cytotoxic, antibacterial, and antifungal properties of ethanolic extract of Allium Saralicum R.M. Fritsch leaves rich in linolenic acid, methyl ester. *Journal of Photochemistry and Photobiology B: Biology*, *192*(January), 103–112. https://doi.org/10.1016/j.jphotobiol.2019.01.017

Khan, N., Shahid, S., Ahmed, K., Wang, X., Ali, R., Ismail, T., & Nawaz, N. (2020). Selection of GCMs for the projection of spatial distribution of heat waves in Pakistan. *Atmospheric Research*, *233*, 104688. https://doi.org/10.1016/j.atmosres.2019.104688

Koç, E., İşlek, C., & Üstün, A. (2010). Effect of cold on protein, proline, phenolic compounds and chlorophyll content of two pepper (Capsicum annuum L.) varieties. *Gazi University Journal of Science*, *23*, 1–6.

Moebius-Clune, B. N., Moebius-Clune, D. J., Gugino, B. K., Idowu, O. J., Schindelbeck, R., Ristow, A. J., van Es, H. M., & Thies, J. E., Shayler, H. A., McBride, M. B., Kurtz, K. S. M., Wolfe, D. W., and Abawi, G. S. (2016). *Comprehensive assessment of soil health* (31st ed.).

Nugroho, A., Heryani, H., Choi, J. S., & Park, H. (2017). Asian Paci fi c Journal of Tropical Biomedicine scavenging activity. *Asian Pacific Journal of Tropical Biomedicine*, *7*(3), 208–213. https://doi.org/10.1016/j.apjtb.2016.12.009

Onyedikachi, U. B., Nkwocha, C. C., Ejiofor, E., & Nnanna, C. C. (2024). Investigation of chemical constituents, antioxidant, anti-inflammatory and nutritional properties of oil of Persea americana (Avocado) seeds. *Food Chemistry Advances*, *5*(June 2023), 100770. https://doi.org/10.1016/j.focha.2024.100770

Rahmi, A., & Biantary, M. P. (2014). Karakteristik Sifat Kimia Tanah Dan Status Kesuburan Tanah Lahan Pekarangan Dan Lahan Usaha Tani Beberapa Kampung Di Kabupaten Kutai Barat. *Ziraa'ah*, *39*(1), 30–36.

Santi, T. D. (2015). Uji Toksisitas Akut dan Efek Antiinflamasi Ekstrak Metanol dan Ekstrak n-Heksana Daun Pepaya (Carica papaya L). *Pharmaceutical Sciences and Research*, *2*(2), 101–114. https://doi.org/10.7454/psr.v2i2.3341

Santi, T. D. (2019). Effect of Moderate Physical Activity to Muscle Fatigue on Untrained People. *IOP Conference Series: Materials Science and Engineering*, *506*(1), 0–5. https://doi.org/10.1088/1757-899X/506/1/012028

Santi, T. D., & Candra, A. (2023). Skrining Fitokimia Dan Karakteristik Salep Daun Averrhoa bilimbi. *BIOMA : Jurnal Biologi Makassar*, *8*(1), 23–31. https://journal.unhas.ac.id/index.php/bioma/article/view/23338

Santi, T. D., & Candra, A. (2024). Analisis Senyawa Fitokimia Daun Moringa Oleifera Dari Kawasan Geotermal Aceh Besar Sebagai Kandidat Antiinflamasi. *Media Penelitian Dan Pengembangan Kesehatan*, *34*(4), 857–866. https://doi.org/https://doi.org/10.34011/jmp2k.v34i4.2638

Santi, T. D., Candra, A., Amin, F. A., & Rizki, C. M. F. (2025). Ethnopharmacological Study of Medicinal Plants in Gampong Atong, Aceh Besar. *Proceeding of International Conference Social Technology Education and Health Science*, *2*(1), 1–7. https://proceeding.umpri.ac.id/index.php/ISTEHS/article/view/71/80

Santi, T. D., Candra, A., & Zakaria, R. (2023). Counseling and Training of Intervention Model Local Plants to Overcome Stunting (TALAS) for Health Workers at Montasik Health Center, Aceh Besar. *IRPITAGE*, *4*(2), 287–291. https://doi.org/https://doi.org/10.54443/irpitage.v4i2.2041

Santi, T. D., Siregar, T. N., Sutriana, A., Andini, R., & Candra, A. (2022). Phytochemical test and optimization of transdermal patches of Carica papaya extract : Formulation design of candidate drug for wound healing. *Biodiversitas*, *23*(6), 2904–2913. https://doi.org/10.13057/biodiv/d230617

Santi, T. D., Siregar, T. N., Sutriana, A., Andini, R., & Candra, A. (2023). Wound Healing Activity of Transdermal Patches of Carica Papaya, Chromolaena Odorata, and Averrhoa Bilimbi Leaves on Incision Wounds of Hyperglycemic Rat. *Trends in Sciences*, *20*(12), 6944. https://doi.org/https://doi.org/10.48048/tis.2023.6944

Santi, T. D., Zakaria, R., Candra, A., & Dharma Nauval, M. (2023). Analysis Active Compounds of Carica papaya, Averrhoa bilimbi, and Chromolaena odorata Leaves from Geothermal Area. *AIP Conference Proceedings*, *2583*(January). https://doi.org/10.1063/5.0116236

Seigler, D. S., Pauli, G. F., Nahrstedt, A., & Leen, R. (2002). Cyanogenic Allosides and Glucosides from Passiflora Edulis and Carica Papaya. *Phytochemistry*, *60*, 873–882.

Ullya, J., Santi, T. D., & Arlianti, N. (2024). Faktor Risiko Kejadian Diabetes Melitus Pada Lansia Awal (Umur 46-

55 Tahun) di Wilayah Kerja Puskesmas Ingin Jaya Kabupaten Aceh Besar. *MAHESA : Malahayati Health Student Journal*, *4*(2), 612–622. https://doi.org/10.33024/mahesa.v4i2.13688

Wadekar, A. B., Nimbalwar, M. G., Panchale, W. A., Gudalwar, B. R., Manwar, J. V., & Bakal, R. L. (2021). Morphology, phytochemistry and pharmacological aspects of Carica papaya, an review. *GSC Biological and Pharmaceutical Sciences*, *14*(03), 234–248. https://doi.org/10.30574/gscbps.2021.14.3.0073